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SEPARATION OF HELIUM ISOTOPES AND OTHER NEW WORK IN THE FIELD OF LOW TEMPERATURE PHYSICS AT THE PHYSICS INSTITUTE, ACADEMY OF SCIENCES UKRAINIAN SSR

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A number of interesting papers by members of Prof B. G. Lazarev's Laboratory /of Low Temperature Physics, Physics Institute/, Academy of Sciences Ukrainian SSR, was presented at the session of the Department of Physicomathematical and Chemical Sciences, Ukrainian SSR, which took place on 25-28 April 1950. Prof Lazarev, director of the laboratory reported on the separation of helium isotopes, a subject which he investigated together with B. N. Esel'son and I. M. Lifshits, Corresponding Member of the Academy of Sciences, Ukrainian SSR.

These authors have succeeded in developing a new method for the enrichment of helium with isotope He^3, which is more efficient than the methods used hitherto. The concentration of He^3 according to the new method proceeds in two steps. The initial enrichment by a factor of about 2,000 is carried out under utilization of the thermomechanical effect. In the course of this process, He^4 is removed together with the super-conducting phase from liquid helium that has a temperature which is below the lambda transition point. Using this process, the authors obtained within 7 days 4.3 liters of helium having a concentration of the light isotope amounting to 0.01%. The second step of the enrichment, which increases the concentration of the light isotope by a factor of 150, could be carried out very rapidly with the aid of a miniature distillation column. In one of the experiments, 22 cubic centimeters of helium having a 1.5% concentration of the light isotope could be obtained from the 4.3-liter fraction mentioned above.

The production of sizable quantities of helium having a rich He^3 content made it possible to carry out a number of experiments with He^3 solutions in He^4. First of all, it was shown that an increase in the concentration of He^3 in helium displaces the lambda transition point in the direction of lower temperatures. For a 1.5%-concentration of He^3 this displacement was found to be equal to 0.03°, while in the case of a 0.34% concentration the displacement was less than the limit of experimental error, which is estimated at 0.005°.

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It is known that the rate of flow of He II from a vessel with a high level of liquid to a vessel with a low level of liquid does not depend on the difference of levels. This relationship holds only until a certain very low difference of levels is reached; after that point, the rate of flow exhibits a linear dependence on the difference of levels. According to the authors, this effect is due to the fact that as a result of the transference of He II flow into the other vessel, an osmotic pressure arises which balances a certain difference of levels. On the other hand, a difference of vapor pressures of He^3 is produced over the liquids due to differing concentrations of this isotope. This results in transference of He^3 through the gas phase, while He^4 flows through the film.

Several other papers describing investigations in the field of low temperature physics were presented at the meeting. A paper by Ye. S. Borovik dealt with the Hall effect in metals under the action of fields having a strong magnetic effect. The strong effect of the magnetic field is achieved by cooling the metal to a very low temperature. In view of the fact that the conductivity of the metal greatly increases at the low temperature, one must conclude that the free path of the electron is greatly increased. Consequently, the action of the magnetic field on the electron running through the distance of the free path is correspondingly augmented, so that ordinary magnetic fields exert effects which at higher temperatures could be matched only by very strong fields.

The author characterizes the Hall effect by the dimensionless quantity E_y ... [illegible.], which expresses the relation of the Hall electric field to the electric field in the direction of the current. In a group of metals represented by zinc and beryllium, this quantity passes through a maximum when the magnetic field increases. In another group, of which indium is an example, the ratio expressed by this quantity increases indefinitely with an increasing magnetic field. The observed phenomena in the first approximation are found to be in agreement with the theory based on the bizonal model of a metal having an equal number of electrons and holes. However, the independence of Hall's constant on the magnitude of the magnetic field, which is predicted by the theory, cannot be demonstrated experimentally. In the case of metals of the beryllium and zinc type, this independence can be observed only under the limiting conditions of very weak or very strong fields.

B. I. Verkin, in a paper entitled "Magnetic Properties of Metals at Low Temperatures," described the results of an investigation carried out together with Prof B. G. Lazarev and M. S. Rudenko. The authors established that the periodic variation of the magnetic moment which has been observed on single crystals of bismuth and zinc when the intensity of the external field is changed apparently represents a property which is common to all metals, because they were able to observe it on a considerable number of additional metals, i.e., cadmium, beryllium, magnesium, tin, and indium. For different metals, this phenomenon is observed in different temperature ranges, with very different values of the external field and widely differing magnitudes of the period.

The crystals exhibit magnetic anisotropy expressed by an angular dependence of the magnetic susceptibility arising when the crystal is rotated with reference to the direction of the magentic field. According to existing theories, this anisotropy must be absent in the basal plane of the crystal. To check this matter, measurements were carried out on single crystals oriented in such a manner that the vector of the field, when disposed in the basal plane of the crystals, could form various angles with the binary axes. Under the conditions studied, anisotropy of the magnetic properties of crystals, as well as a periodic dependence of the magnetic susceptibility on the intensity of the field, appeared at sufficiently low temperatures.

[redacted]

A. A. Galkin and P. A. Bezuglyy clarified the problem indicated by the title of their paper "On the Frequency Dependence of the Detection of Alternating Currents With the Aid of Superconductors." In regard to this paper, it has been shown previously in the course of work done at B. G. Lazarev's laboratory that the phenomenon of disturbance of the superconducting state can be utilized for detecting an alternating current, and that the possibility of detection extends to radio frequencies. The frequency characteristics of this type of detection were investigated on thallium. Repeating this work on tin, foreign authors came to the conclusion that in the range of audio frequencies higher than 20,000 cycles the quality of tin as a detector improves with higher frequencies. Galkin and Bezuglyy's results on thallium do not agree with this finding.

Galkin and Bezuglyy have shown that the results obtained with tin can be explained by nonisothermic conditions existing during the experiment. The heat transmission coefficient of He I being small, dispersion of transition heat that is free of inertia cannot be achieved in experiments in which He I is used. Consequently, the process of transition becomes almost adiabatic, which leads to an increase of critical currents and an impairment of the detector characteristics.

I. M. Lifshits, in discussing the question, "On Kinetics of the Destruction of the Superconductive State by a Magnetic Field," started from the premise that the time of relaxation of phenomena of the superconductive state is apparently very small. Consequently, at frequencies of alteration of the magnetic field which are not too high these phenomena may be neglected and a treatment of the problem from the macroscopic standpoint can be carried out.

This amounts to the formulation of certain electrodynamic and thermodynamic conditions comprising a relationship to the effect that changes of the field bring about the appearance of Foucault currents in the sample. These currents prevent movement of the boundary between the normal and the superconducting phase. On the other hand, heating of the sample produced by Foucault currents expedites movement of this boundary. Development of the corresponding electrodynamic and heat conductivity equations leads under certain conditions to a solution of the isothermic problem for low frequencies.

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